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SLUDGE HANDLING AND ULTIMATE DISPOSAL

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Environmental Protection Agency
Cincinnati, Ohio

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17

SLUDGE HANDLING AND ULTIMATE DISPOSAL*

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INTRODUCTION

The disposal of sludges from municipal wastewater treatment facilities can account for up to 50 percent of the total treatment cost.[1]

The purpose of this presentation is to discuss some alternative methods for the stabilization, dewatering, and ultimate disposal of the sludges. Particular attention is given to in-house research work of the Environmental Protection Agency's Ultimate Disposal Program.

Sludge can be defined as the settleable solids that are naturally present in water and wastewater, or that are formed from non-settleable matter by chemical coagulation and precipitation, and by biological flocculation and precipitation. It is a semi-liquid waste which flows, can be pumped, exhibits hindered settling characteristics, and is usually brown to black in appearance. Odors may or may not be present.

Tighter effluent criteria and the resultant construction of additional secondary facilities, increasing land scarcity, and population pressure have combined to make sludge disposal more difficult and expensive than ever before.

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SLUDGE QUANTITIES AND CHARACTERISTICS

The approximate amounts of sludge produced in the treatment of wastewater by simple gravity sedimentation, chemical treatment, and biological processes are shown in Table 1. The least amount of sludge is generally produced by either simple sedimentation alone or in conjunction with a trickling filter. On the other hand, if chemical addition is practiced or the activated sludge process is included in the processing sequence, large additional quantities of sludges can be expected, necessitating the construction of larger facilities.

TABLE 1

APPROXIMATE QUANTITIES OF SLUDGE
PRODUCED BY DIFFERENT TREATMENT PROCESSES

Treatment	Quantity of Sludge Produced[2] (Gallons/million gallons wastewater treated)
Plain Sedimentation	2,980
Trickling Filter Humus	681
Chem. Precipitation	5,142
Activated Sludge	18,025

The moisture quantities of some typical wastewater treatment plant sludges are shown in Table 2. This table indicates that the water content of all sludges is high. To interpret the results in a somewhat different fashion, a raw primary sludge would contain approximately 19 lbs. of water for every pound of sludge solids, while a waste activated

sludge may contain as much as 65 lbs. of water for every pound of sludge solids. It is obvious that additional treatment is required before incineration can be considered. It should be noted that approximately three pounds of water can be evaporated for every pound of sludge solids present and combustion be sustained without the need for supplemental fuel.[3] Unfortunately, the sludges with the highest water content, the biological sludges are the hardest to dewater. Unless treated in some way, they cannot be economically dewatered.

TABLE 2

TYPICAL MOISTURE CONTENT OF SLUDGES

Treatment	% Moisture	Pounds of Water/Pound Sludge Solids
Primary Sedimentation	95	19
Chem. Precipitation	93	13.3
Trickling Filters		
Humus-Low Rate	93	13.3
Humus-High Rate	97	32.4
Activated Sludge	98-99	~65.6
Well Digested Sludge		
Primary Treatment	85-90	~ 7.0
Activated Sludge	90-94	~11.5

SELECTION OF TREATMENT AND ULTIMATE DISPOSAL ALTERNATIVES

From the previous section, the existence of a disposal problem is apparent. In picking a disposal process, the pollution potential, aesthetics, and economics of the process must be considered. There are biological, chemical, and physical methods available to us and these are shown in Figure 1. In choosing the optimum process for complete sludge

WHICH ONE IS THE BEST????

Chemical Treatment

inorganic conditioners
organic conditioners
recovery fertilizer

Biological Treatment

aerobic
anaerobic
enzymes
composting

Physical Treatment

freezing
heat
filtration
thickening

Ultimate Disposal

land spreading
strip mines
ocean disposal
incineration
land fill
dry fertilizer

Tons and Tons of Sludge

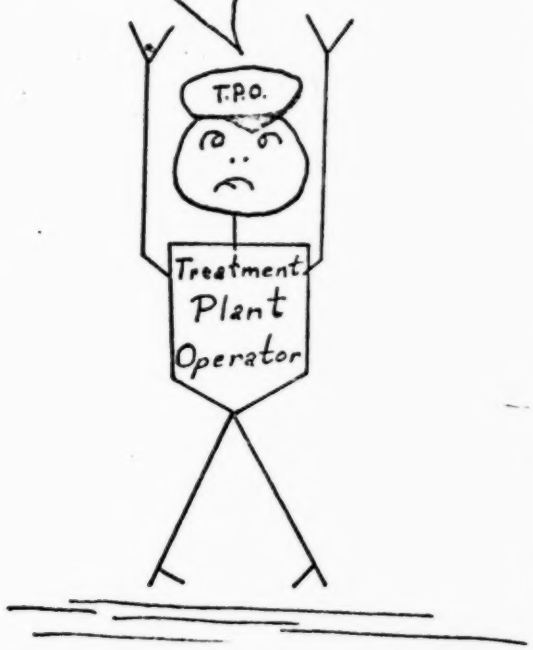

FIG. 1

DEWATERING ALTERNATIVES

handling, one is normally required to think in terms of (1) a stabilization technique, (2) some means for conditioning of the sludge prior to dewatering, (3) a dewatering process and (4) a means for ultimate disposal. Each of these procedures will now be briefly looked at.

STABILIZATION TECHNIQUES

Biological, physical, and chemical means of stabilization are discussed in this section.

Aerobic

Aerobic stabilization is usually designed for a long retention time of 15 to 30 days. Biological steps occurring include: (1) the direct oxidation of any biodegradable matter by the biologically active mass of organisms; and (2) oxidation of microbial cellular material. This process has aroused much interest where a demand for small treatment plants exists. It is simpler to operate than an anaerobic digester and requires a smaller capital expenditure. It is also aesthetically more acceptable in that the resultant sludge is odor-free and suitable for disposal by land spreading or land fill. Other advantages to the process include (1) reduction in pathogenic microorganisms, (2) grease removal, and (3) a supernatant which requires little treatment. Important parameters in this process are air requirements, time of aeration, sludge age, filterability, settleability, and drainability of the product. The disadvantages include high operating cost and unclear design criteria. At present some manufacturers of aerobic digestion equipment and consultants are designing aerobic digestion processes for detention times

of five days. The literature seems to indicate that in the future we may have thermophilic aerobic digestion processes in which the job can be done in even shorter periods than five days.

Anaerobic

Anaerobic digestion is the biological conversion of organic matter in the absence of molecular oxygen to simple compounds. Typically a 50 percent reduction in volatile solids has been obtained by this process. End products of the conversion are chiefly methane and carbon dioxide. The methane gas generated has frequently been used for heating and to run generators. Control of the digesters has often been difficult because of the sensitivity of the microorganisms to toxicity, and the fact that capital costs are high. The supernatant produced in digestion can present a treatment problem, since it is often high in BOD, solids, and nutrients.

Lime Addition

A revolutionary and, from our point of view, economically promising, idea was stabilizing sludge with lime addition in preference to biological digestion. This treatment could either be used prior to land spreading of sludge or before placing it on drying beds. In the case of lime with an elevation of pH to approximately 11.5, the elevated pH and also possibly the production of ammonia in the sludge are responsible for destruction of microorganisms. Studies by us in the laboratory and at Lebanon, Ohio and by Doyle[4] have indicated that in all instances obnoxious odors and pathogenic microorganisms were almost instantly eliminated by treatment with lime. The approximate quantity of hydrated lime required per

ton of raw primary sludge solids is 350 lbs. at a cost of about $2.80.

Pasteurization

In some instances, particularly in Europe, sludge has been pasteurized for health purposes prior to spreading on land. There have remained, however, questions as to the actual health benefits gained by pasteurizing sludge. In our laboratory, raw sludge, digested and activated sludges were pasteurized. Biological analysis of the end product indicated that all pathogenic microorganisms were killed by the pasteurization process. Pathogens were present, however, in all sludges not treated.

TECHNIQUES FOR CONDITIONING OF SLUDGE PRIOR TO DEWATERING

Initially in almost every circumstance some preparation for conditioning of the sludge is required to facilitate mechanical dewatering.

Chemical Addition

Numerous methods for the chemical treatment and conditioning of sludges to assure satisfactory dewatering are and have been explored to assess their effects in the preparation of sludge for dewatering. The Ultimate Disposal Program recently made a study into the chemical conditioning of activated sludge for vacuum filtration. A large number of both inorganic and organic sludge conditioners were evaluated. Surprisingly, the most effective inorganic conditioner was found to be sludge incinerator ash. Conclusions from the overall investigation showed

that in almost every case the filter yield was found to increase with the addition of incinerator ash. The amount of increase depended upon the level of ash addition and the percent solids in the studied sludge. Primary and digested sludges demonstrated up to a threefold increase in filter yield when up to six parts of ash were added for every part of sludge solids present. Activated sludge showed on an average a fivefold increase in filter yield when four parts or more of the ash were added for each part of sludge solids present. Filtrates resulting from the filtration of the ash conditioned sludge were significantly lower in suspended solids, TOC, and total phosphorus than filtrates from filtration of unconditioned sludge. The cake moisture in some instances was found to increase for incinerator ash conditioned sludge.

Freezing

Freezing is found to greatly enhance the ability of a sludge to be dewatered. Under present conditions, however, natural freezing with its limitations is being looked upon with much more favor than are the artificial processes because of their poor economics.

Natural freezing of sludges generated by the addition of alum to both natural and synthetic secondary effluents was investigated as a process for improving their dewaterability. Snow cover, the available environment, completeness of freezing, sludge depth, method of application, and organic content were found to be important variables. Sludge after complete freezing was found, upon thawing, to rapidly settle and filter with a magnitude of improvement of three to four times.[5]

Heat Treatment

The Zimmerman Process oxidizes the organic matter in sludge by contacting air and sludge in a reaction vessel under sufficient temperature and pressure. Operating conditions range from 350 to 600°F and 120 to 3000 psig. Up to 90 percent of the organic matter can be removed by this process. At lower operating temperatures and pressures the system becomes a form of sludge conditioning. The Zimmerman Process is marketed by the Sterling Drug Company. Another heat conditioning process is the Porteous which is marketed by the B.S.P. Corporation and involves the pressure cooking of sludge at 370°F. Sludge is hydrolyzed, living cells and spores are killed, and filtration is made easier. A similar process marketed under the name of Farrar by the Dorr-Oliver Company also is a form of sludge conditioning. All these heat conditioning techniques have one problem in common and that is production of a supernatant which normally requires further treatment and presents an additional load on the sewage treatment process. This load often contains soluble nutrients and a high BOD.

DEWATERING PROCESSES

In most instances the sludge must be further dewatered prior to ultimate disposal. Although I do not intend to cover it as a separate topic, thickening is frequently utilized to reduce the solids level prior to dewatering. The thicker the sludge the more efficient will the dewatering process operate. Thickening is usually done by either a flotation technique where rising gas bubbles are used to increase the buoyancy of the solid particles or by the use of gravity.

Drying Beds

One of the more common methods of handling digested sludge is to pump it out onto sand drying beds, where the excess water is removed by percolation and evaporation. Important factors are the depth of applied solids, concentration of the solids, the available environment for drying, and the particular media used. The technique usually requires considerable land area. The finished product will contain from 50 to 60 percent water.

Vacuum Filtration

This process is practiced on all sludge types. Typically the filter will consist of a cylindrical revolving drum, 4 to 8 feet in diameter which is partially submerged in a tank of sludge. As the drum revolves, sludge is picked up by the vacuum. Excess water is sucked into the center of the drum, leaving a sludge cake on the filter cloth. The sludge is removed from the filter by low pressure air and a shear plate. While the moisture content of the raw sludge may range between 90 and 97 percent, the moisture content of the sludge cake will range between 70 and 80 percent. Major factors influencing performance include the type of sludge, kind of conditioner used, drum cycle time, drum submergence, vacuum, and media.

Centrifugation

All centrifuges used in wastewater treatment are sedimentation type units. The conveyor or scroll unit which is the most popular has adjustable weirs for the bowl or pond depth. It is not recommended

for alum or activated sludge but is good for raw and digested sludges. It operates at approximately 3000 G forces.

ULTIMATE DISPOSAL

In choosing the method to use, you should be sure that it is in accordance with interstate, state and Federal requirements. One should endeavor to insure that the method chosen will not result in any significant degradation of surface or ground water, air, or land surfaces. No sludge residues, grit, ash, or other solids should be discharged into the receiving waters or plant effluent. Sludge disposal to ocean waters is not recommended if toxic materials may be transmitted to the aquatic food chain. Ultimate disposal is the final treatment process. It transforms the sludge in some instances and places it at its final site.

Land Spreading

Digested and anaerobically stabilized sludge may be used for fertilizer or soil supplement. Raw sludge presents health and nuisance problems. Transportation costs must be considered.

FERTILIZER VALUE OF BIO-OXIDATION SLUDGE

Nitrogen	1-5%	Phosphate	1-3%
Potash	0.1 - 0.3%		

Anaerobic digestion will reduce these values 40-50%.

The main advantage to land spreading is the economy in most areas. It is an ultimate method since there is no ash to dispose of. When properly done, it is a way of utilizing nutrients, water and organic material to promote soil productivity and crop yields, and it is nuisance free.

Disadvantages created when improperly done are nuisance conditions, health hazards, the accumulation of toxic metals which may result and nitrate contamination of ground water can occur.

The quantity of sludge that may be spread is a function of the soil characteristics, climate, land use or intended crop, and the type and solids content of the sludge. Two major uses of land spreading of sludge at present are to reclaim low quality land and improve soil and crop productivity. Typical application rates for sludge are for a corn field, 10 - 30 tons of solids per acre per year and for a strip mine about 1,000 tons of solids per acre per year. Again each situation should be evaluated for its own merits. This method is attractive because you do not have to first dewater your sludge or condition it, and you do not have to pay for heat of evaporation.

Incineration

Incineration in either a multiple hearth or a fluidized bed furnace is a method of ultimate disposal in which the sludge, either raw or digested, is burnt and reduced to combustion gases, or ash. Multiple hearth furnaces range in capacity from 200 - 8,000 pounds per hour of dried sludge, and operate at 1700°F. B.S.P. and Nichols are major manufacturers of multiple hearth furnaces and can assist in designing.

In a fluidized bed furnace, the mechanically dewatered sludge is fed into a fluidized sand bed that is supported by air at 3.5 to 5 psi. The fluid bed reactor has a single chamber unit in which moisture evaporation and combustion of organics takes place simultaneously under oxidizing

conditions at 1400 - 1500°F. Major manufacturers of fluidized bed furnaces are Dorr-Oliver and Copeland Corporations.

When properly operated, sludge incinerators are relatively air pollution free compared to a solid waste incinerator. Consideration must be given however to the quantity of air pollutants discharged.

UNIQUE METHODS FOR HANDLING SLUDGES

It is necessary in an area such as ours which is responsible for a major cost portion of treating waste water to finance a few projects which seemingly are far out in the hope that by chance they will yield a result which would greatly cut the cost of sludge handling. Some of the projects which fall in this category and which are supported by the Environmental Protection Agency's Water Quality Office and monitored by the Ultimate Disposal Research Program are listed below together with their level of financing.

Company Receiving Grant or Contract	Project Financed	Level of Financing
Rocketdyne, Canoga Park, California	Electro-osmosis as a Technique for Sewage Sludge Dewatering	$ 79,966
Clemson University Clemson, South Carolina	Fermentation of Sewage Sludges to Useful Products	$ 89,000
Aerojet-General Corp. El-Monte, California	Biological Methods of Sludge Dewatering (Enzymes)	$ 93,000

The costs for some typical sludge handling process combinations are presented below.

COSTS

Process	Costs	Source
1. Digestion + Sand Bed Dewatering	$25/ton	Burd[6]
2. Pipelining to Sea or Land Disposal	$3-7/ton	Cleveland[7]
3. Barging to Sea	$9/ton	New York[8]
4. Digestion and Reclamation of Farm Land	$15/ton	Chicago[9]
5. Digestion and Reclamation of Strip Mine	$16/ton	"
6. Drying and Selling as Fertilizer (net)	$45/ton	"
7. Digesting and Lagooning	$49/ton	"
8. Wet Air Oxidation (Zimpro)	≤ $50/ton	"
9. Dewatering and Incineration	$57/ton	"
10. Chemical Conditioning Followed by Vacuum Filtr.	$20/ton	Balakrishnan[10]

SUMMARY

The solving of any waste problem requires first that attention be given to good housekeeping to see if some waste sources can be reduced and second that consideration be given to reuse of waste components.

In any sludge disposal problem, it is essential to consider the character of the sludge, the availability of land, the possible use of the sludge as a fertilizer, and capital and operating costs.

This paper has attempted to present the presently available methods and their costs and some of those which are being researched for disposal of sludge solids. Treatment plant space, nuisance problems, economics, and health are involved.

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